MSFC-904

Environmental Public Health Surveillance for Exposure to Respiratory Health Hazards: A Joint NASA/CDC Project to Use Remote Sensing Data for Estimating Airborne Particulate Matter Over the Atlanta, Georgia Metropolitan Area

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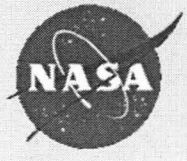
Public Health Surveillance

- Ongoing systematic collection, analysis, and interpretation of outcome-specific data used to plan, implement, and evaluate public health practice.

Surveillance Information Uses

- Monitor & detect changes in the magnitude & distribution of selected events
- Develop hypotheses for research
- Evaluate interventions
- Facilitate public health decision-making



Types of PH Surveillance

- Prevalence
  - All cases
- Incidence
  - Newly diagnosed cases
- Active
  - Health department initiated
- Passive
  - Health care provider initiated

CDC's National Environmental Public Health Tracking (EPHT) Program initiated in 2002

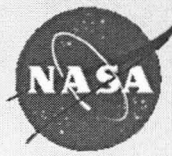
- Congressional funding for *development and implementation of a nationwide environmental health tracking network and capacity development in environmental health at State and local health Departments"*

Selected EPHT Network Features

- Tools for linkage, visualization, analysis, generation of alerts, & reporting
- Internet-based
- Standards-based
- HIPAA compliant
- Access to the network is based on role & purpose

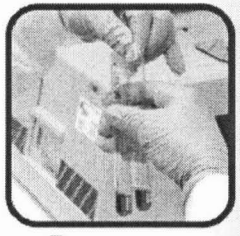
Tracking = Public Health Surveillance

- Environmental public health tracking is the ongoing, systematic collection, integration, analysis, and interpretation of data about the following factors:
  - environmental hazards
  - human exposure to environmental hazards
  - health effects potentially related to exposure to environmental hazards
- Data must be disseminated to plan, implement, and evaluate environmental public health action

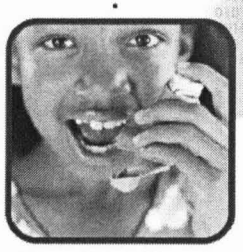


Environmental Public Health Tracking

Hazard



Exposure



Health Effect

Ongoing Evaluation

Data

Tracking Network

COLLECTION → INTEGRATION → ANALYSIS → INTERPRETATION

Dissemination

Stakeholders*

Assessment • Research • Intervention • Policy

Prevention

Improved Public Health

Ongoing Evaluation

*Stakeholders Include	
Federal Agencies	Business and Industry
State and Local Agencies	Policy Makers
Academia	Media
Health Care System	Public
Non-Governmental Organizations	

DEPARTMENT OF HEALTH AND HUMAN SERVICES
CENTERS FOR DISEASE CONTROL AND PREVENTION
SAFER • HEALTHIER • PEOPLE

CDC
SAFER • HEALTHIER • PEOPLE

Health Effects, Exposures, Hazards

Health Effects

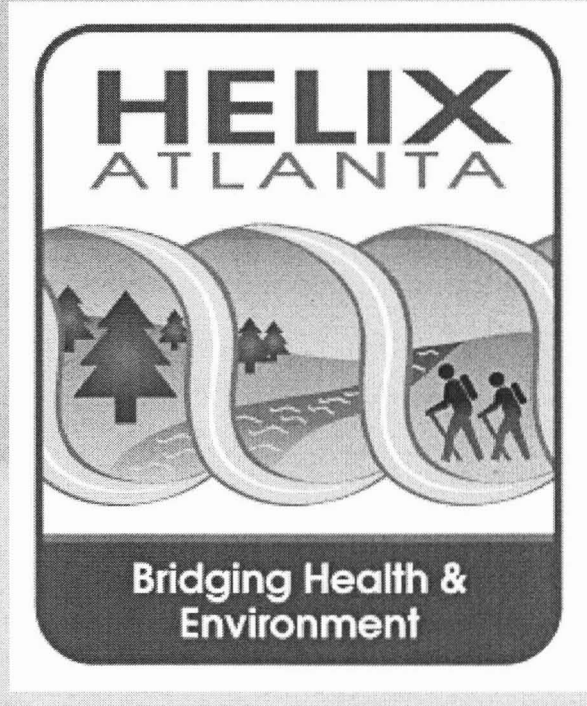
- Asthma
- Poisoning – heavy metal; CO; pesticides
- Cancer
- Birth Defects
- Other adverse reproductive outcome such as low birth wt, preterm birth
- Developmental disabilities
- Other chronic respiratory disease
- Multiple Sclerosis
- Cardiovascular Disease
- Systemic Lupus Erythematosus
- Amyotrophic lateral sclerosis

Exposures/Hazards

- PCBs
- Heavy metals
- Pesticides
- Environmental tobacco smoke
- Radionuclides
- Asbestos
- Other drinking water contaminants such as trihalomethanes, PCE, TCE,
- Outdoor air contaminants such as particulate mater, ozone, CO and air toxics
- Indoor air contaminants such as mold, carbon monoxide

HELIX-Atlanta

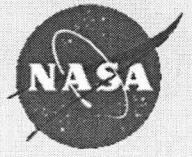
- Provide information regarding the 5-county Metro-Atlanta Area
  - Clayton, Cobb, DeKalb, Fulton, & Gwinett
- Integrate environment & public health data into a local network that is part of a national network
- Take action to prevent & control environmentally related health effects



HELIX-Atlanta

- HELIX-Atlanta was developed to support current and future state and local EPHT programs to implement data linking demonstration projects which could be part of the EPHT Network.
- HELIX-Atlanta is a pilot linking project in Atlanta for CDC to learn about the challenges the states will encounter.
- NASA/MSFC and the CDC are partners in linking environmental and health data to enhance public health surveillance.
- The use of NASA technology creates value – added geospatial products from existing environmental data sources to facilitate public health linkages.
- Proving the feasibility of the approach is the main objective

- Sharing data between agencies with different missions and mindsets
- Protecting confidentiality of information
- Ensuring high quality geocoded data
- Ensuring appropriate spatial and temporal resolutions of environmental data
- Developing sound resources and methods for conducting data linkages and data analysis



HELIX-Atlanta Re[illegible]

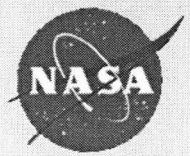
RH Team Pilot Data Linkage Project:

Link environmental data related to ground-level $PM_{2.5}$ (NASA+EPA) with health data related to asthma

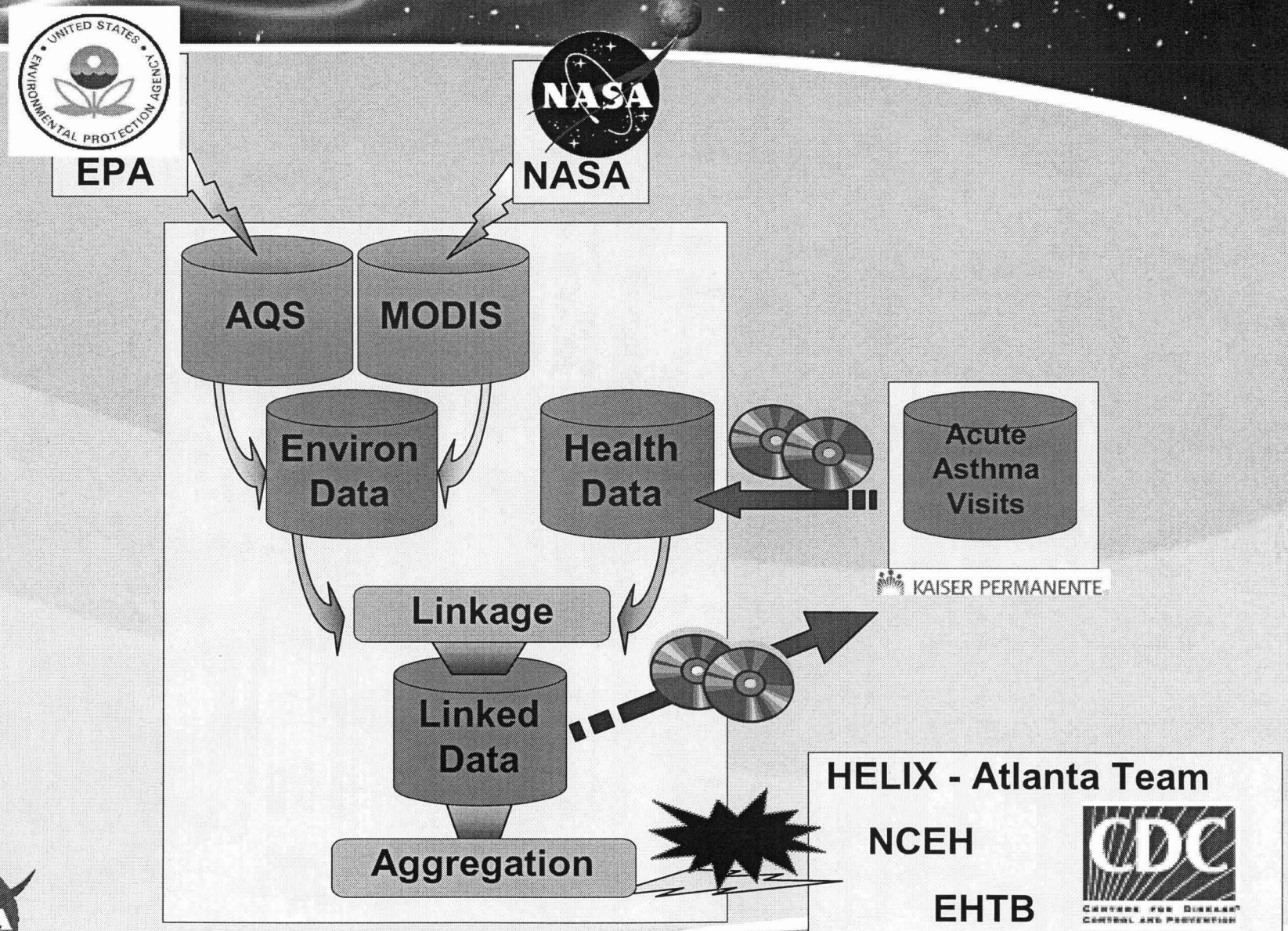
Goals:

1. **Produce and share information on methods useful for integrating and analyzing data on asthma and $PM_{2.5}$ for environmental public health surveillance.**
2. **Generate information and recommendations valuable to sustaining surveillance of asthma with $PM_{2.5}$ in the Metro-Atlanta area.**

Environmental Hazard Measure: Daily $PM_{2.5}$
Asthma Measure: Daily acute asthma office visits to KP-GA Medical Facilities
Time period: 2001-2003
Linkage Domain: 5-county metropolitan Atlanta



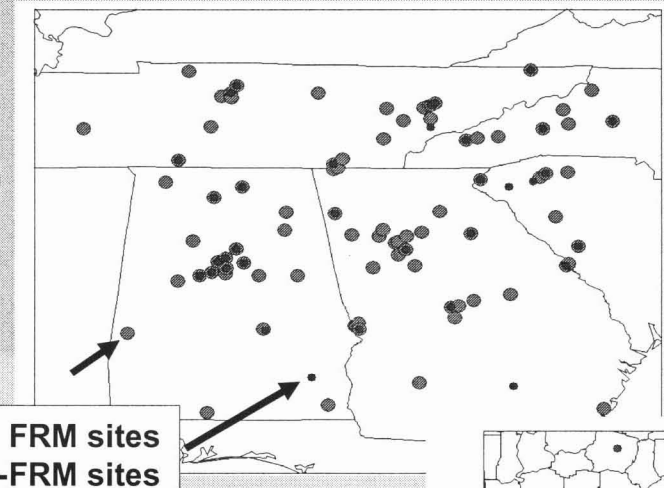
Data Linkage

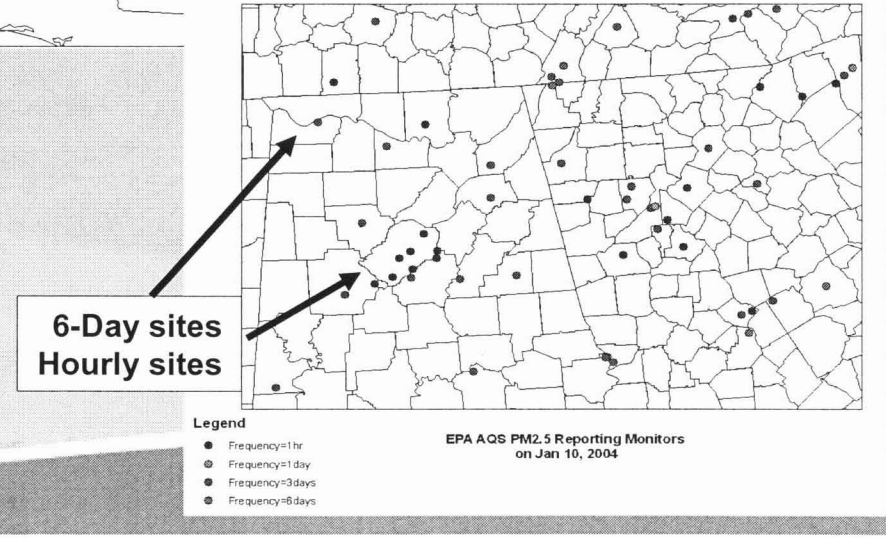


Sources of $PM_{2.5}$

EPA Air Quality System (AQS) ground measurements

- National network of air pollution monitors
- Concentrated in urban areas, fewer monitors in rural areas
- Time intervals range from 1 hr to 6 days (daily meas. every 6th day)
- Three monitor types:
  - Federal Reference Method (FRM)
  - Continuous
  - Speciation
- FRM is EPA-accepted standard method; processing time 4-6 weeks





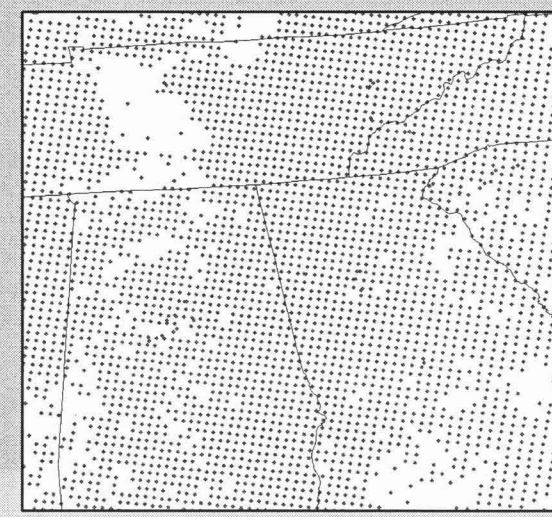
Sources of [illegible]

MODIS Aerosol Optical Depth (AOD)

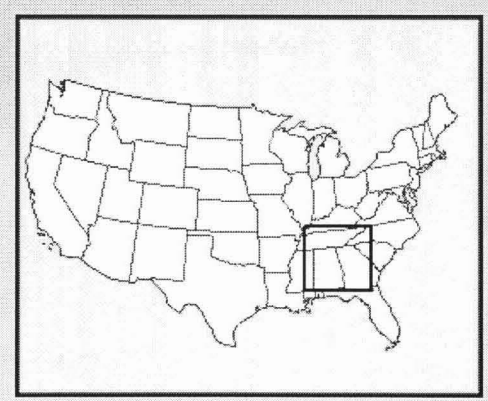
- AOD is a measure of the total particulate in the atmosphere
- If atmosphere is well mixed, AOD is a good indicator of surface $PM_{2.5}$
- Enhanced Spatial Coverage
- Provided on a 10x10 km grid
- Available twice per day

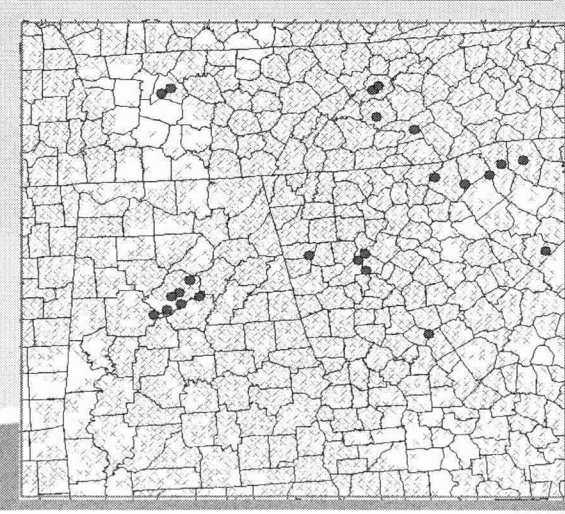
(Terra ~10:30 AM, Aqua ~1:30 PM)

- Clear-sky coverage only
- Available since spring 2000



MODIS



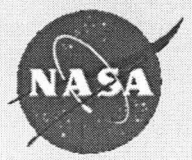


AQS

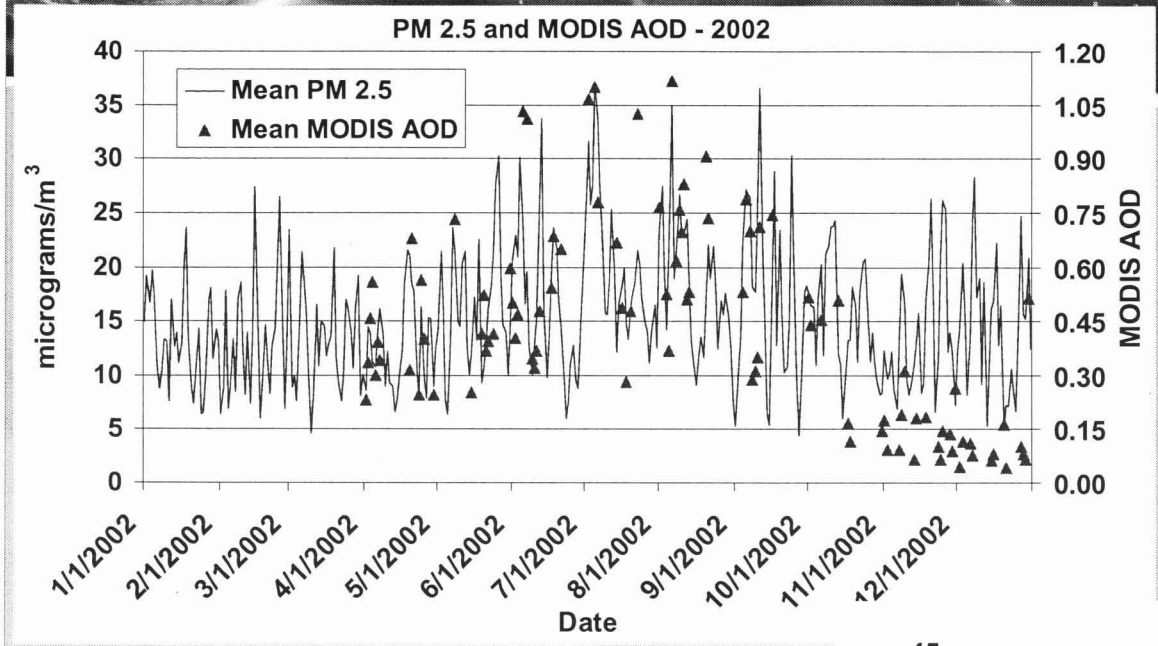
June 25, 2003

Estimating $PM_{2.5}$ from MODIS data

- For 2002-2003, obtain MODIS AOD and EPA AQS $PM_{2.5}$ data
- Extract AOD data for 5 AQS site locations
- Calculate daily averages from hourly AQS $PM_{2.5}$ data
- Using daily $PM_{2.5}$ averages from all 5 Atlanta AQS sites, determine statistical regression equations between $PM_{2.5}$ and MODIS AOD
- Apply regression equations to estimate $PM_{2.5}$ for each 10 km grid cell across region



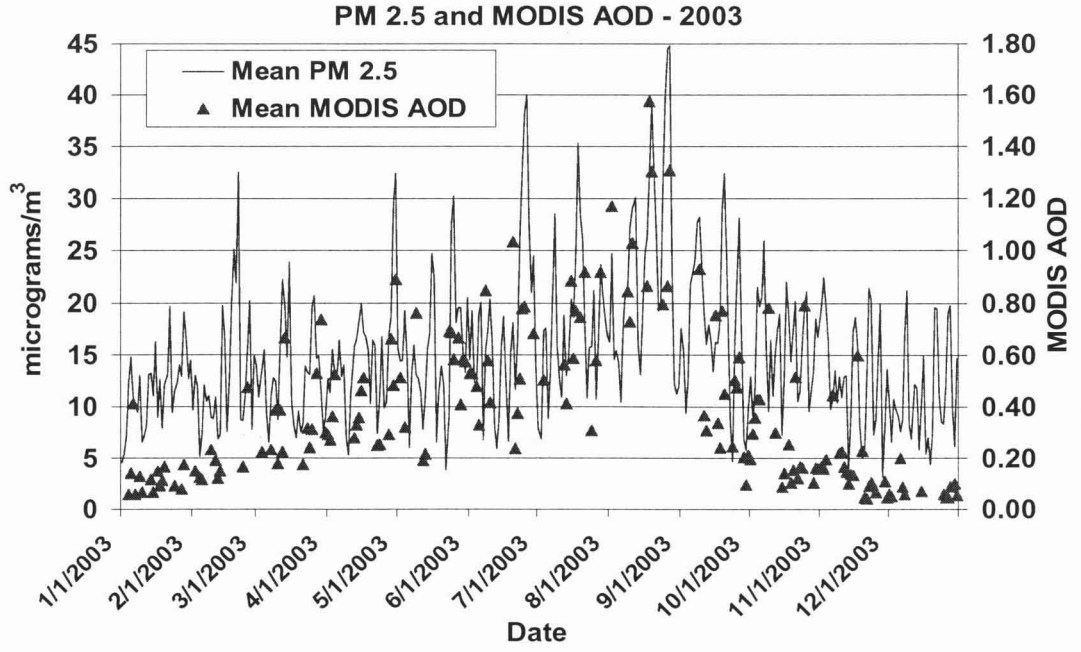
MODIS AOD



- Daily 5-site means of observed $PM_{2.5}$ and MODIS AOD
- MODIS data not available every day due to cloud cover
- MODIS AOD follows seasonal patterns of $PM_{2.5}$ but not the day-to-day variability in fall and winter

2002

2003



PM 2.5 – MODI

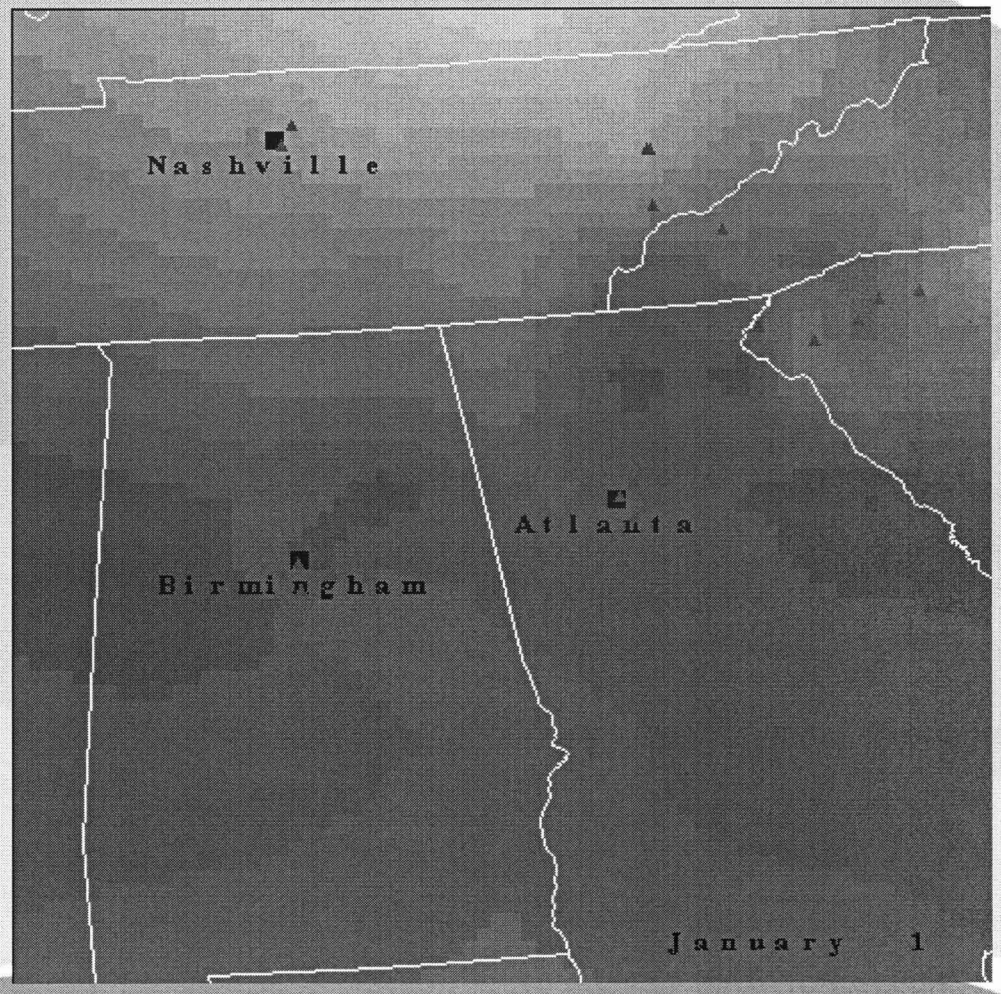
April - September

	MODIS-Terra	MODIS-Aqua
2000 -->	0.579	
2001 -->	0.643	
2002 -->	0.559	0.401
2003 -->	0.661	0.727

- Correlations between $PM_{2.5}$ and MODIS AOD are generally high (> 0.55) for the warm season.
- The lower correlation for MODIS-Aqua in 2002 is for July-September only.

PM2.5 Exposure Asse

- 1st degree recursive B-spline in x- and y-directions
- Inverse Distance Weighted (IDW)
- Daily surfaces created on a 10x10 km grid
- Variable number of measurements available each day



$PM_{2.5}$ Concentration

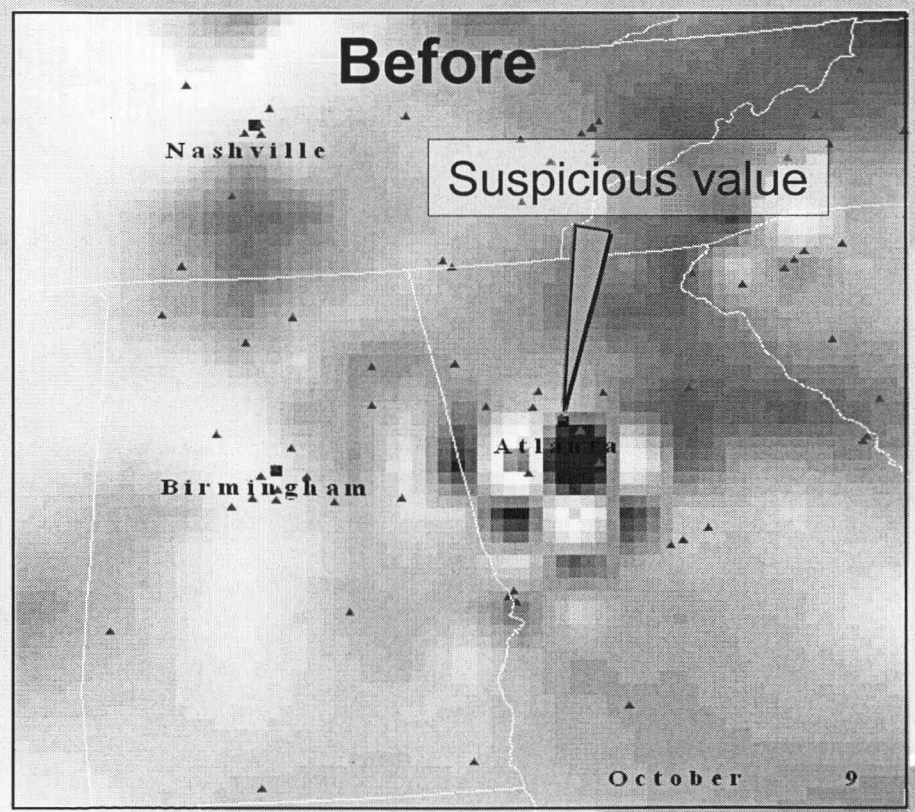
High : 50 μg/m^3

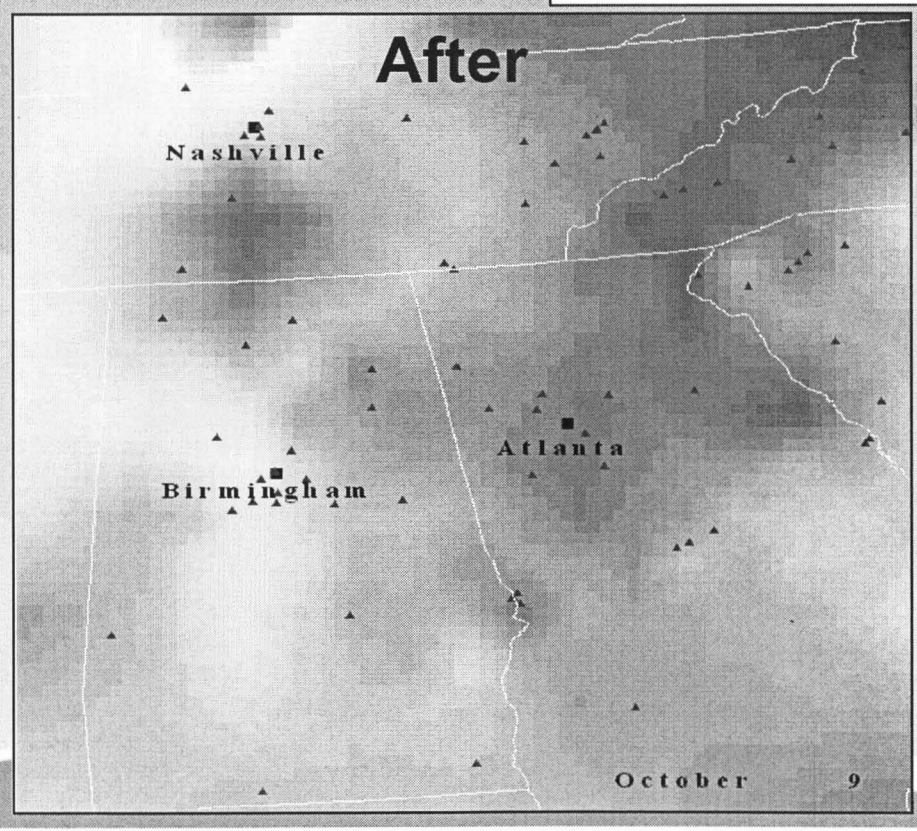
Low : 0 μg/m^3

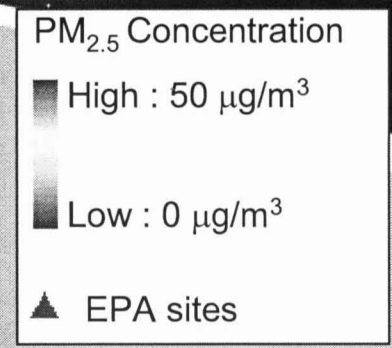
EPA sites

Quality Control Pro

- Eliminates anomalous measurements based on a non-parametric rank-order spatial analysis
- Applied to all daily AQS $PM_{2.5}$ measurements before spatial surfaces are built



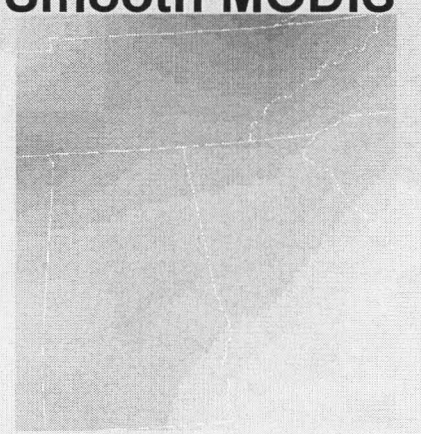




MODIS $PM_{2.5}$

- Assumption: AQS measurements are unbiased relative to the local mean, but MODIS $PM_{2.5}$ estimates may have biases.
- Procedure:
  1. Use a two-step B-spline algorithm to create highly smoothed versions of the MODIS and AQS $PM_{2.5}$ daily surface
  2. Compute the 'Bias' as the difference between the smoothed fields
  3. Subtract the bias from the MODIS $PM_{2.5}$ daily surface to give the 'bias-corrected' MODIS daily surface

Smooth MODIS



—

Smooth AQS

65 μg/m³

0 μg/m³

=

MODIS Bias

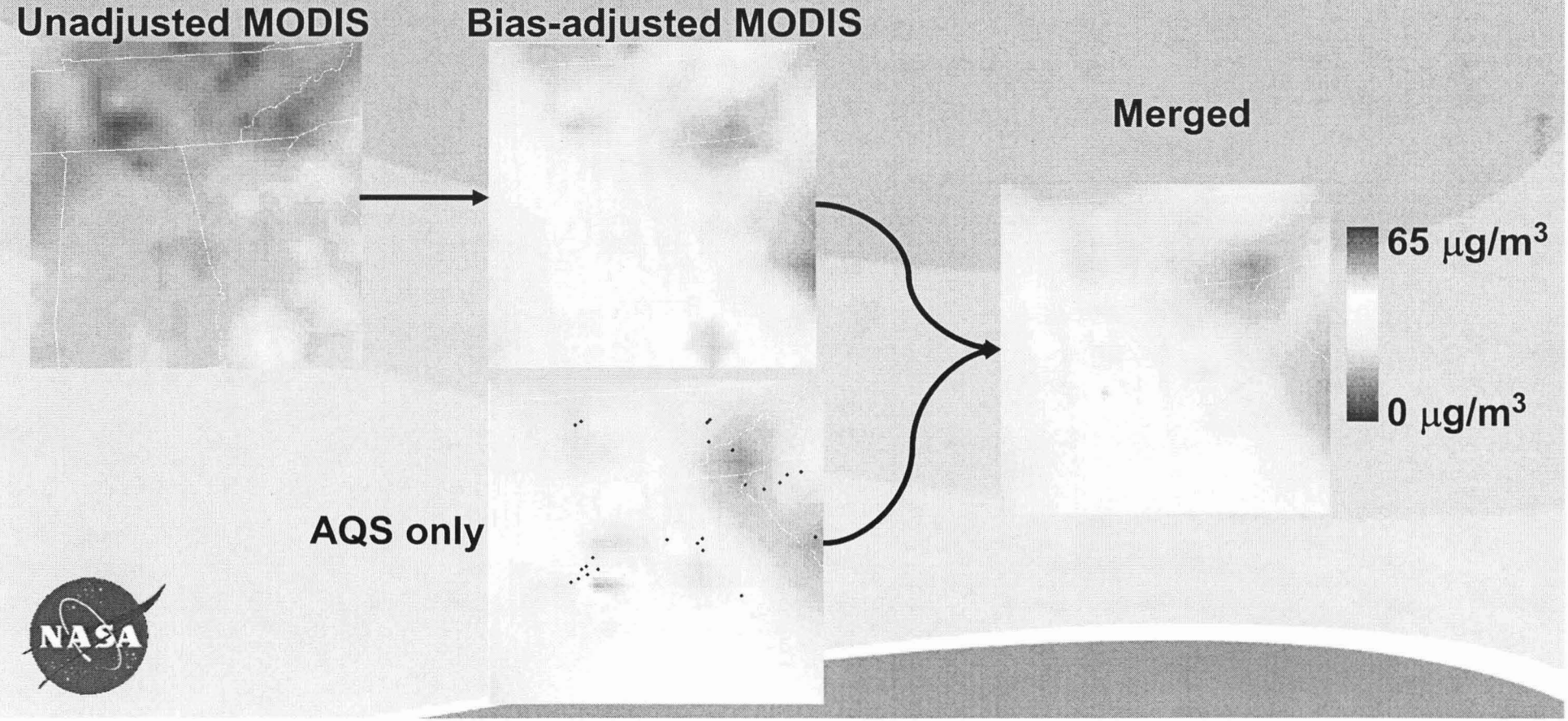
10.6 μg/m³

-22.9 μg/m³

Merging MODIS

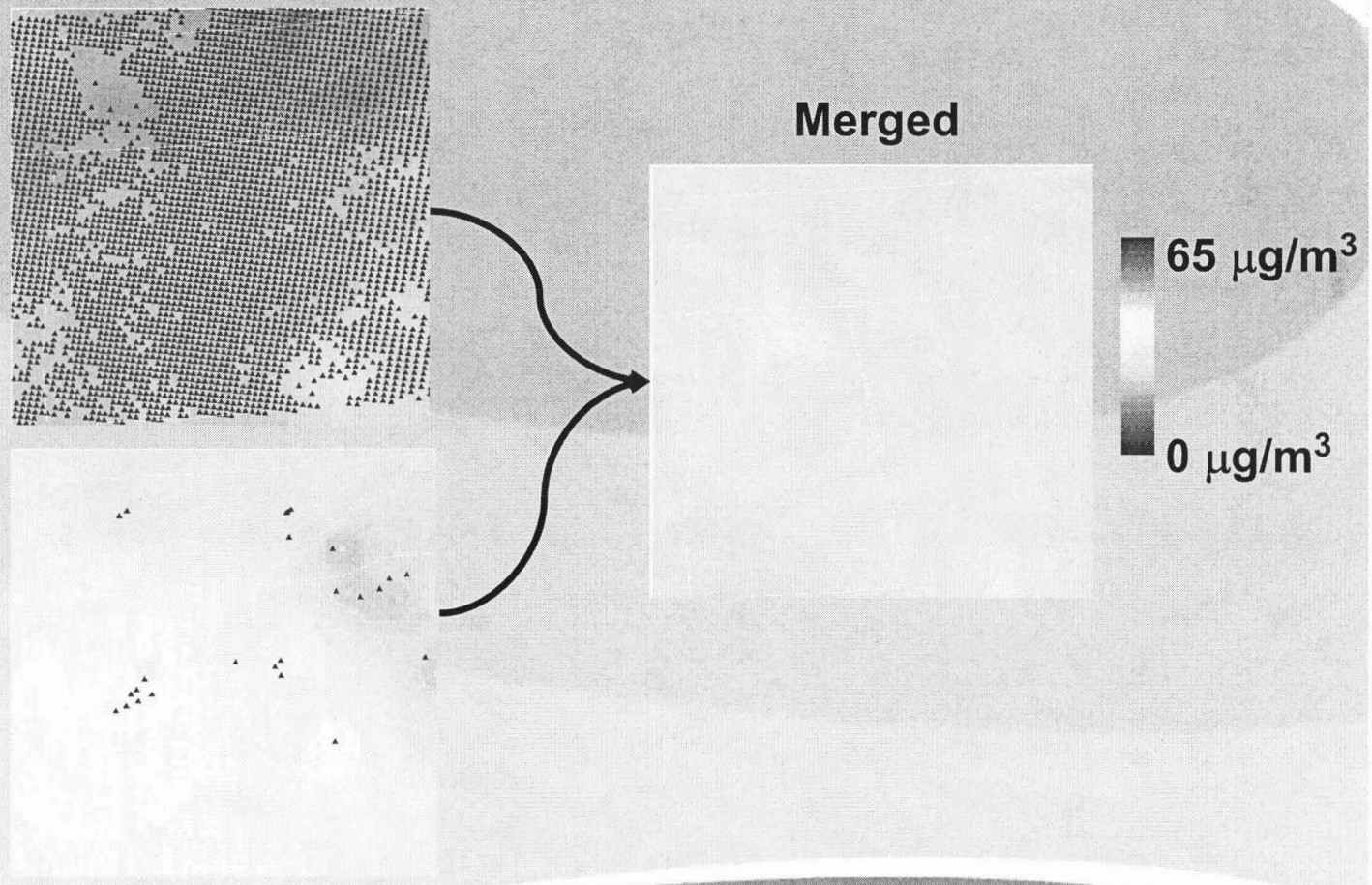
- MODIS and AQS data have been merged to produce final $PM_{2.5}$ surfaces.

B-Spline Surfacing



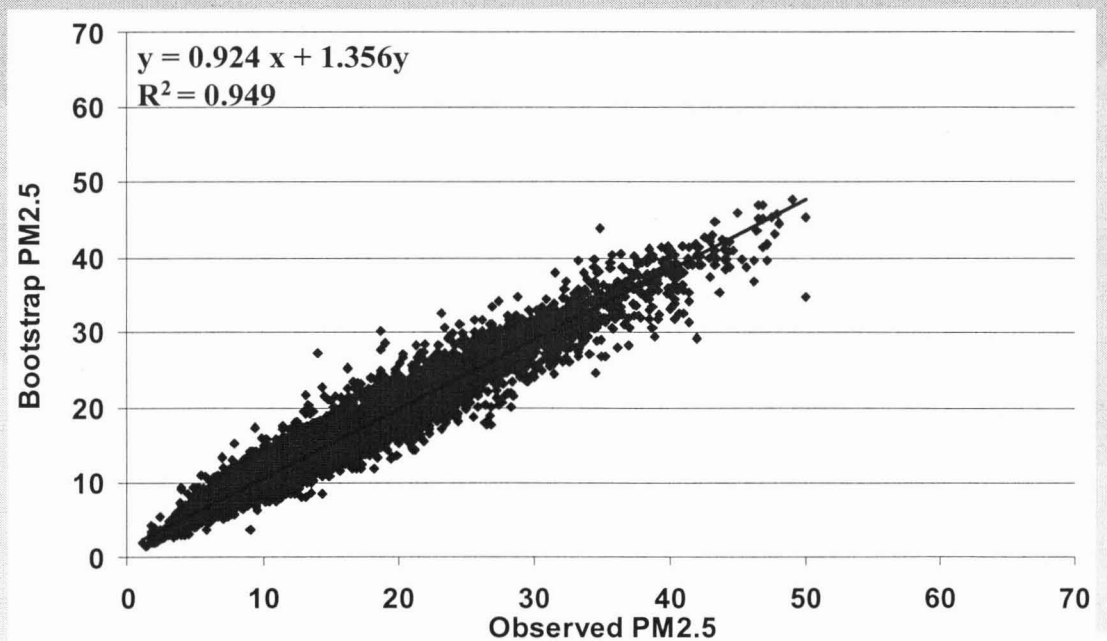
Merging MODIS

IDW Surfacing



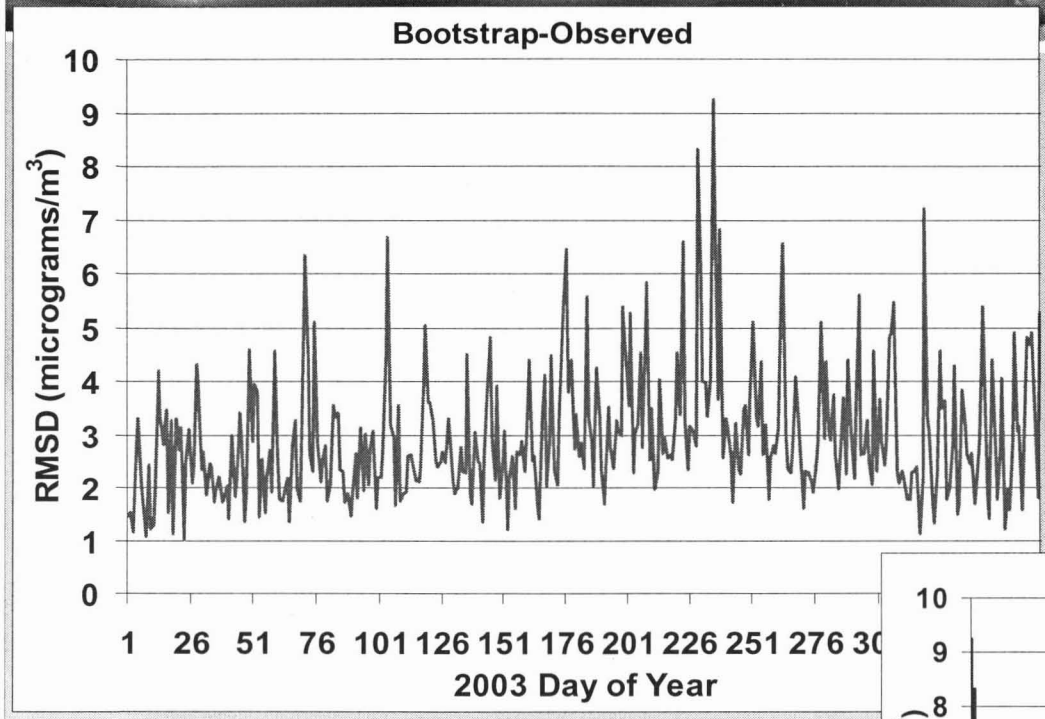
Cross-v

- a.k.a. 'bootstrapping' or 'omit-one' analysis
- Objective: Estimate errors associated with daily spatial surfaces
- Procedure:
  1. Omitting one observation, create surface using N-1 observations
  2. Compare value of surface at location of omitted observation with the observed value
  3. Repeat for all observations
  4. Calculate error statistics by day or site

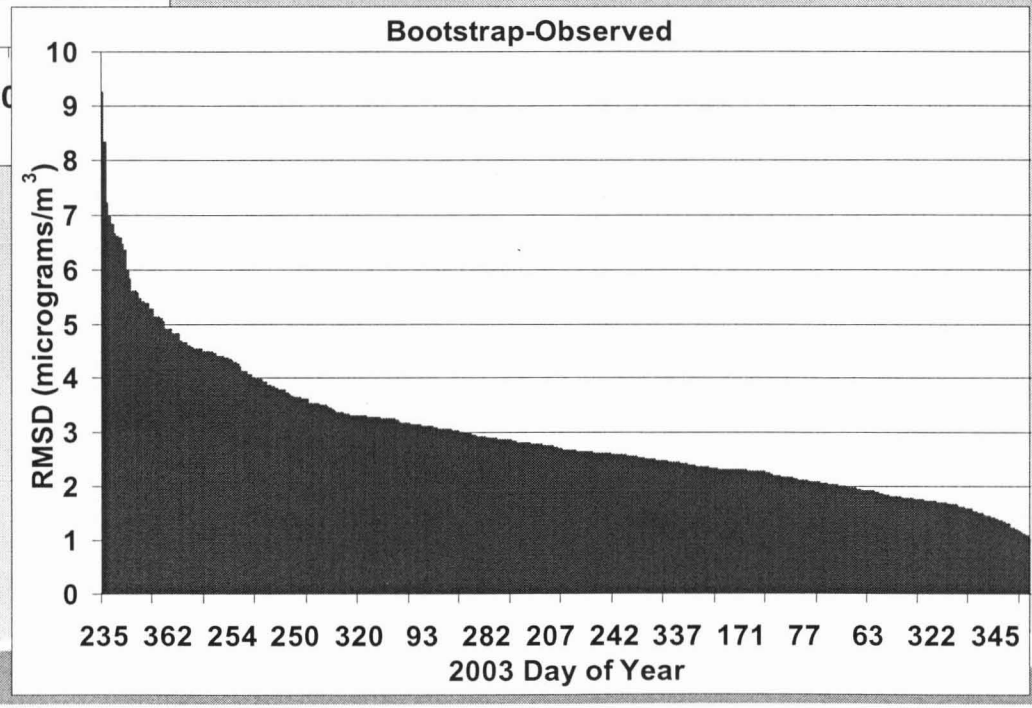


Cross-Val

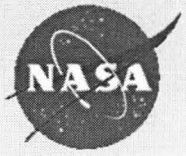
Daily Error Sta



Time Series



Rank Order



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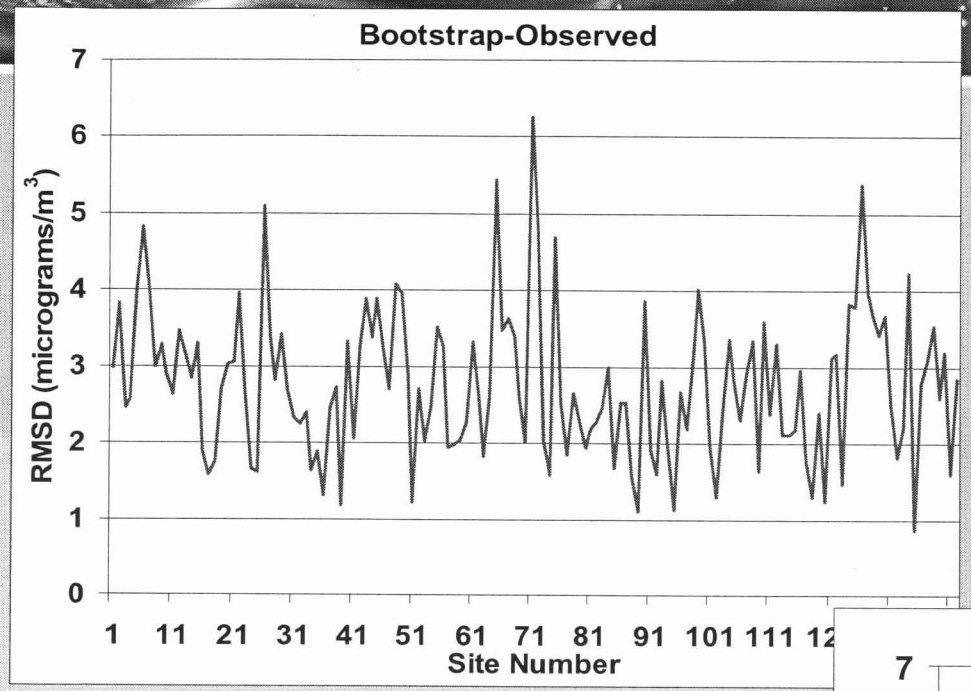
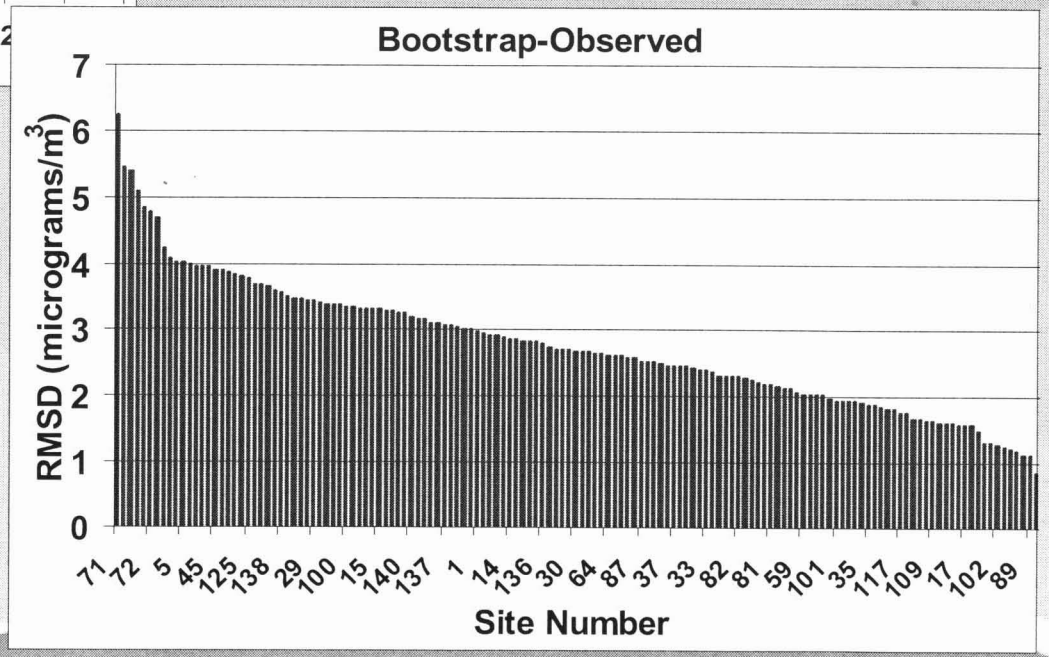
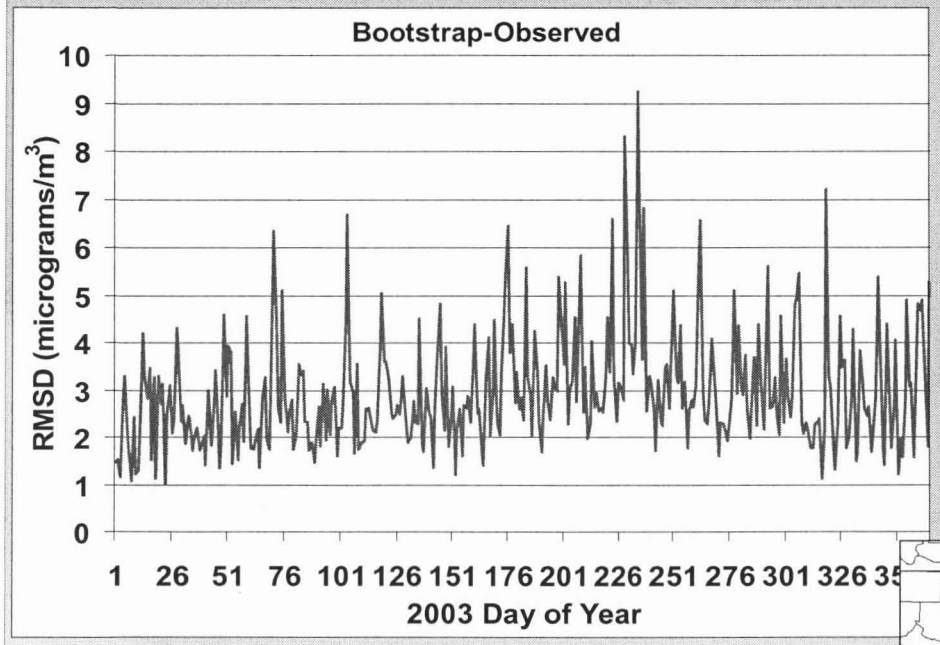


RMSD by Site



Rank Order

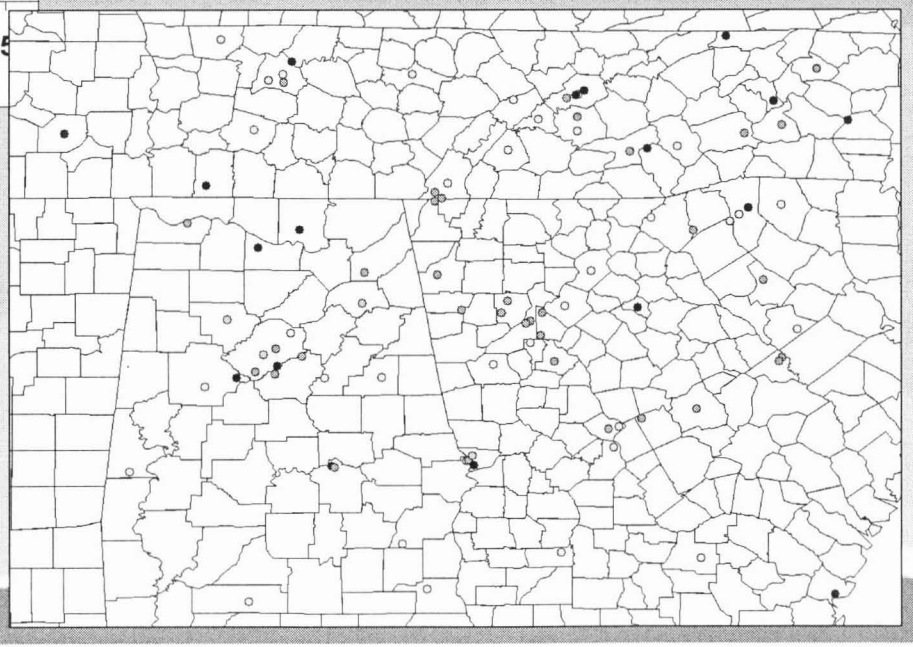
Cross Error Statistics



Time Series

RMSD = 2.7 μg/m^3

RMSD by Site



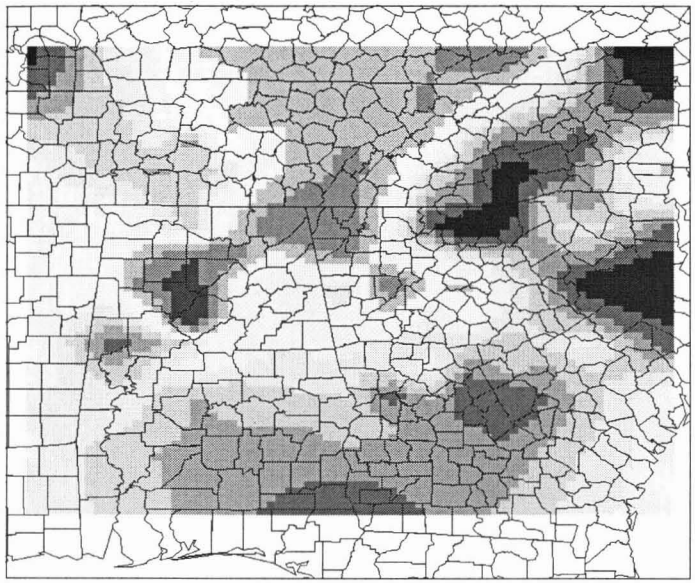
Surfacing Meth

Surfacing Technique and Data Source	RMSD (All Days)	RMSD (Warm Season - Days 91-273)
Bspline, AQS only, no QC	3.30	3.56
Bspline, AQS only, with QC	2.93	3.16
IDW, AQS only	2.45	2.69
B-Spline, merged AQS/MODIS	N/A	2.76
IDW, merged AQS/MODIS	N/A	1.61

Surfacing Technique and Data Source	Improvement
Bspline: QC vs. No QC	12 %
Bspline: AQS only vs. merged AQS/MODIS	16 %
IDW: AQS only vs. merged AQS/MODIS	40 %

Annual Comp

PM2.5 B-Spline Surfaces Year 2003 Composite

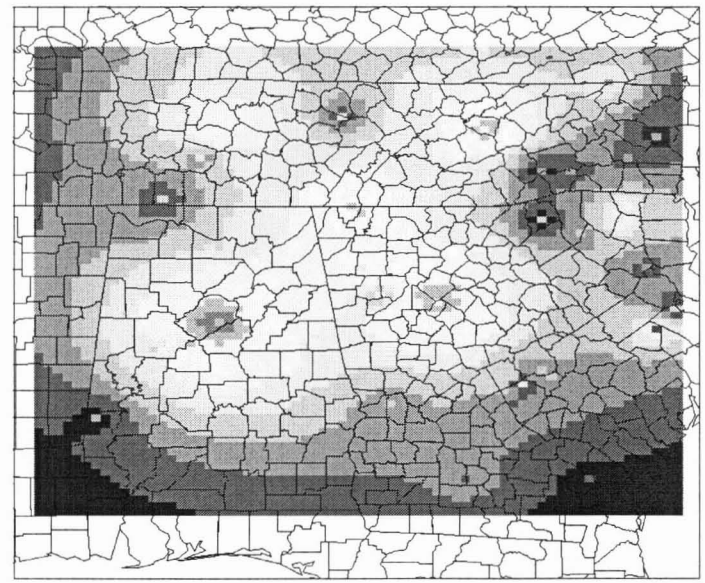


PM2.5 (ug/m^3)

- 10.24 - 11.97
- 11.98 - 12.57
- 12.58 - 12.97
- 12.98 - 13.35
- 13.36 - 13.74
- 13.75 - 14.23
- 14.24 - 14.85
- 14.86 - 15.54
- 15.55 - 16.50
- 16.51 - 18.36

B-Spline

PM2.5 IDW Surfaces Year 2003 Composite



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- 13.75 - 14.23
- 14.24 - 14.85
- 14.86 - 15.54
- 15.55 - 16.50
- 16.51 - 18.36

IDW

Linkage of Env

Health Data Set

Members

LON	LAT	ID	AGE	GENDER	YEAR/MO
-84.207	99.200	1	Child	M	200301
-84.802	99.359	2	Adult	M	200301
-83.798	99.993	4	Child	F	200301

Acute asthma office visits

ID	AGE	LON	LAT	GENDER	DATE
1811	Child	-84.179	99.118	F	1/1/2003
54767	Adult	-84.625	99.802	F	1/1/2003
84580	Adult	-84.679	99.691	F	1/1/2003

*Simulated Data Set. F=female, M=male, A=adult, C=child.

Linkage of Envi

Data Linkage Outputs

Visit counts by grid cell

Date	Cell	PM2.5	FC	MC	FA	MA
200301	1	21.74	1	0	2	0
200301	2	12.79	0	0	0	0
200301	3	12.21	0	1	0	1

$PM_{2.5}$ for each visit

Date	ID	Member Lat/Lon		Cell	Cell Lat/Lon		County	State	Gender	Age	PM2.5
1 1	1811	99.572	-84.251	1944	99.552	-84.284	Coweta	GA	F	Child	21.74
1 2	15299	99.063	-83.860	1608	99.104	-83.806	Upson	GA	F	Child	12.79
1 2	15879	99.727	-84.369	2079	99.731	-84.403	Fulton	GA	M	Child	12.21

*Simulated Data Set. F=female, M=male, A=adult, C=child.

Public Hea

Cholera Deaths Soho, London August-September, 1854

Legend

- Streets
- Wells
- Grid

Cholera Deaths Per Residence

COUNT

- 1 - 2
- 3 - 4
- 5 - 6
- 7 - 10
- 11 - 18

Integration Radius = 55m
Grid Spacing = 40m

N

0 50 100 200 Meters

12/15/05 10:35am
Dr. Mohammad Al-Hamdan
USRA at NASA/MSFC
HELIX-Atlanta Project
mohammad.alhamdan@nasa.gov

*Original data were published by C.F. Cheffins, Lith, Southhampton Buildings, London, England, 1854 in Snow, John. On the Mode of Communication of Cholera, 2nd Ed, John Churchill, New Burlington Street, London, England, 1855.
**Digital Data of Streets, Wells, and Deaths Residences which were used to creat this surface were downloaded from the UCLA Department of Epidemiology Website at http://www.ph.ucla.edu/epi/snow.html.

Public Hea

Cholera Deaths Soho, London August-September, 1854

Legend

- Streets
- Wells

Deaths Per Unit Area

COUNT

- 0 - 1
- 1 - 5
- 5 - 10
- 10 - 15
- 15 - 20
- 20 - 25
- 25 - 30
- 30 - 35
- 35 - 40
- 40 - 45
- 45 - 50
- 50 - 55
- 55 - 63

Integration Radius = 55m
Grid Spacing = 40m

N

Meters
0 50 100 200

12/15/05 10:35am
Dr. Mohammad Al-Hamdan
USRA at NASA/MSFC
HELIX-Atlanta Project
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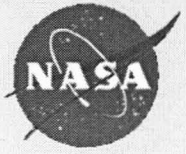
*Original data were published by C.F. Cheffins, Lith, Southampton Buildings, London, England, 1854 in Snow, John. On the Mode of Communication of Cholera, 2nd Ed, John Churchill, New Burlington Street, London, England, 1855.
**Digital Data of Streets, Wells, and Deaths Residences which were used to creat this surface were downloaded from the UCLA Department of Epidemiology Website at http://www.ph.ucla.edu/epi/snow.html.


The Red Granite kerbstone
marks the site of the historic
BROAD STREET PUMP
associated with Dr. John Snow's
discovery in 1854
that Cholera is conveyed by water


NASA

Succ

- Proven the feasibility of linking environmental data (MODIS $PM_{2.5}$ estimates and AQS) with health data (asthma)
- Developed algorithms for QC, bias removal, merging MODIS and AQS $PM_{2.5}$ data, and others…
- Negotiated a Business Associate Agreement with a health care provider to enable sharing of Protected Health Information



Acknowledgements

Member's Name, Affiliation

- (*Co-Chair)* Kafayat Adeniyi, Centers for Disease Control and Prevention,
- (*Co-Chair)* Solomon Pollard, Environmental Protection Agency (EPA), Region 4
- Mohammad Z. Al-Hamdan, National Aeronautics and Space Administration
- Rob Blake, DeKalb County Board of Health
- David Blaney, Georgia Division of Public Health
- Bill Crosson, National Aeronautics and Space Administration
- Kristen Mertz, Georgia Division of Public Health
- Amanda Sue Niskar, Centers for Disease Control and Prevention
- Dale Quattrochi, National Aeronautics and Space Administration
- Amber Sinclair, Kaiser Permanente
- Allison Stock, Centers for Disease Control and Prevention
- Denis Tolsma, Kaiser Permanente
- Linda Thomas, Environmental Protection Agency, Region 4
- Ntale Kajumba, Environmental Protection Agency, Region 4
- Carolyn Williams, Georgia Division of Public Health

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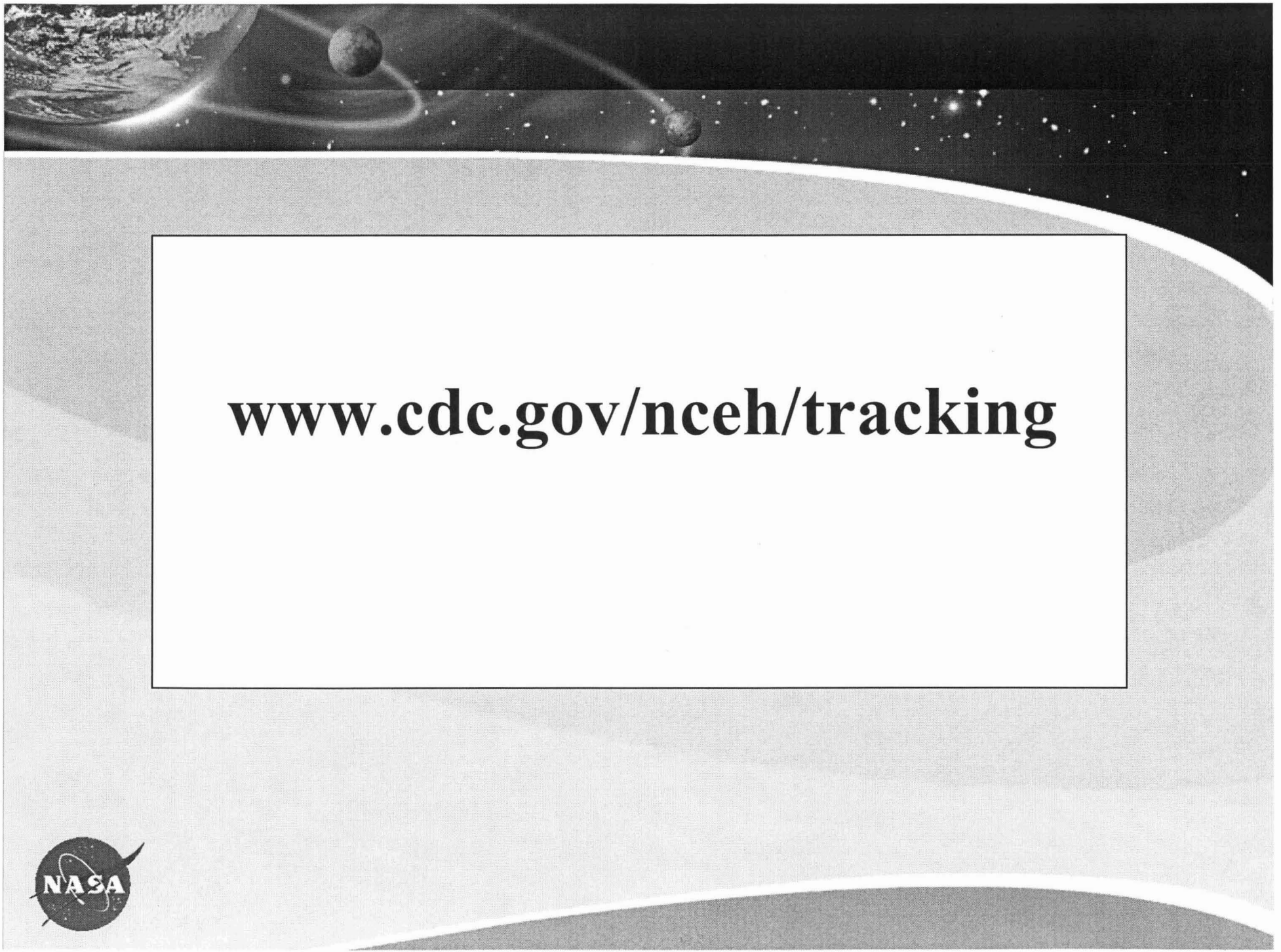
- Gabriel Rainisch, Centers for Disease Control and Prevention
- Emily Hansen
- HELIX-Atlanta Partners



www.cdc.gov/nceh/tracking